BOTANY

By Correspondence

Interstate
School of
Correspondence
Chicago

BOTANY BY CORRESPONDENCE

BY

C. H. SYLVESTER

Formerly of the State Normal School at Stevens Point, Wis.

BASED UPON

BERGEN'S

FOUNDATIONS OF BOTANY AND KEY AND FLORA

STUDIES AND TEST QUESTIONS

CHICAGO

INTERSTATE SCHOOL OF CORRESPONDENCE

STRUCTURE, FUNCTIONS AND CLASSIFICATION

PLANT RELATIONS

A CORRESPONDENCE COURSE IN BOTANY

BASED UPON
BERGEN'S *FOUNDATIONS OF BOTANY*, AND *KEY AND FLORA*

INTRODUCTORY

The correspondence student in any science must not expect to master his course by reading only. He must observe, and experiment with as great care as though he were in a well-equipped laboratory. This is most easily done in botany, where the apparatus required is simple and the experiments by no means difficult. Barring the work with the compound microscope, there is no reason why he should not thoroughly master the subject as presented in Bergen's text. Minute structures and studies with the compound microscope he must accept without demonstration unless he is so fortunate as to have access to an instrument. In the latter case the book tells him how to proceed.

The following apparatus is essential:

Simple Microscope.—This the school furnishes with the text-book.

Scalpel or Knife.—A sharp, thin-bladed knife for making sections.

Dissecting Needles.—Take two coarse sewing needles and thrust the head of each into a handle

about four inches long and the size of a common penholder. Taper the ends down to the needles, and the instruments are complete.

Paper.—A good, unruled drawing paper is desirable, but most of your work can be done on legal cap or other paper such as you have.

Pencil.—A good, medium pencil for drawing and note taking.

This completes the list of essential things. These should be prepared in advance and kept always in readiness for use.

A certain amount of work with plants is a necessary part of this course. Without it a clear understanding of the text is practically impossible. The student should make up his mind to collect and prepare the material required for study and experiment, and should have a definite time and place for his work. If he omits no work that is practicable and goes earnestly into every experiment that is possible to him, he will certainly gain that habit of close, scientific observation and logical inference that is the chief value in the study of botany. The facts of botany are valuable as information, but the habit of clear thinking is of infinitely greater importance. Do not be discouraged at difficulties nor at failures in your earlier work. Skill and success will be certain to come in direct proportion to the effort you put forth.

Use of the Lens.—Provide yourself with a smooth, level surface upon which to work, and arrange it so that the light will fall from above and below upon the

object you are examining. To do this lay a piece of clear glass across two supports about two inches high. For want of a better arrangement, put two books upon the table with the opening between them toward the light, and rest the ends of the glass upon them. Place your microscope over the object. Both hands are now free to work. Regulate the focus of your microscope to suit the part you are to examine. Take one of your dissecting needles in each hand and learn to handle your specimen with them. Your fingers are too large and clumsy: you will soon gain skill in the use of the needles, and your eye will become trained to see through your lens.

Drawing.—You must *draw*—draw much and frequently. Do not be discouraged by your first efforts, nor try to make fine pictures. Represent by simple outline drawings what you see. If you really *see* things, you will soon be able to show other people how they look. Copy some of the simpler drawings from the book till you get a little skill, but make your real drawings direct from the object. Do not try to find a picture like it—draw the object as you see it. Do not try to shade your drawings. Be content with well-proportioned outlines. Draw only the lines you see.

This represents a folded leaf, but it is incorrectly drawn. No one can see all these lines; some are hidden by the upper part of the leaf.

1

The drawing should be like that on page 8.

Fig. 9, page 25, and Fig. 89, page 131, of Bergen are good examples of what you can do with outlines. Of course if you understand drawing, you will enjoy making more elaborate sketches.

2

When you have found what you wish to draw, and the object is in proper position, leave it unmoved till you are through. Make your drawing from a certain point of view. If you wish to represent another view of the specimen, make another drawing. Write enough of explanation near your sketch to make clear everything you have not shown.

Records.—Procure a notebook and keep, for your own satisfaction, a written record of whatever you do, under the date at which it is done. You will be told from time to time what you are to send in to the school for criticism. Such drawings as you send in will be returned to you and you can then file them away in your record.

Finally, consider nothing too simple to be done, nothing too difficult to be attempted. Work faithfully and with ardor—you will soon find your interest growing in the very things that now seem most difficult. If you need help in your work, or are doubtful of any portion at any time, let us know.

WHEN TO BEGIN THE COURSE, AND HOW TO PURSUE IT

Read the following very carefully, several times if necessary, before you begin your studies, and plan your course intelligently.

You can begin the course at any time you like. It is not necessary that the lessons be taken in the order given here, which is the order of the *Foundations of Botany*, though it is a good arrangement when you begin in the autumn. Even then it probably would be better to begin with Lesson V and study the first four lessons during the winter. The essential things are two: First, you must have plants to study; second, you must study plants. This compels you to study Lessons IX, XX, XXI and XXII in the spring. The four lessons contain work enough for April, May and June, to say the least. Again, if the lessons are not taken in the order given here, the Review Lessons (VI, XII and XVIII) should be left to the very last and taken in the order given. Whatever arrangement you follow you will find it necessary to review and review as new material comes to you.

All the lessons, studies, and test questions are sent you at once so that you can follow any order that you find most convenient. The lessons and their subjects are as follows:

I. The Seed. Germination. Storage of Food. Movements, Development and Morphology of Seed.
II. Roots.
III. The Stem and Its Structure.
IV. Structure and Work of Stem.
V. Buds, Leaves and Leaf Arrangement and Movements.
VI. Review.
VII. Structure and Function of Leaves. Protoplasm.
VIII. Inflorescence. Study of Typical Flowers. Plan and Structure of Flowers. Nature and Structure of Floral Organs. Fertilization.
IX. Fruits and the Classification of Plants.
X. Cryptogams. Thallophytes.
XI. Cryptogams. Thallophytes.
XII. Review.
XIII. Cryptogams. Bryophytes and Pteridophytes.
XIV. Evolution. Plant Societies.
XV. Botanical Geography. Relations of Plants to Each Other. How Plants Protect Themselves.
XVI. Ecology of Flowers.
XVII. Distribution and Propagation. Struggle for Existence.
XVIII. Review.
XIX. What the Flora Is.
XX. What the Key Is.
XXI. Use of Key and Flora.
XXII. Systematic Botany.

There is no imperative reason for following any order in these lessons. If you change that of the book you may be caused a little trouble by the use of unfamiliar terms. If so, use the Glossary (page 239 of the *Flora*) and the Index (page 397 of *Foundations*), and learn the significance of the new terms. The three review lessons studied at the end will systematize your knowledge.

Here follow several different possible arrangements of the lessons with a few comments added.

Course I

Beginning in the autumn and continuing the year round. Take the lessons in this order:

Autumn. V, VII, IX, XIII.

Winter. I, II, III, IV, X, XI.

Spring. VIII, XIX, XX, XXI, XXII.

Summer. XIV, XV, XVI, XVII, VI, XII, XVIII.

If you begin to study in the autumn, collect leaves and press them, fruits and lay them aside, mosses, ferns, etc., and press them for use later in the season. There is no good reason why several lessons may not be running at the same time. At any rate do not feel that one must be entirely completed before another is begun. Be independent. If you are working on roots and run out of material, lay that lesson aside and commence on another. When you are through with a lesson, send in to us what is required and work at another lesson. Do not get confused by carrying this idea too far but still rise in a sense superior to your course of study.

Course II

Beginning in the autumn and closing in June.

Autumn. V, VII, IX, XIV, XV, XVI, XVII.

Winter. I, II, III, IV, X, XI, XIII.

Spring. VIII, XIX, XX, XXI, XXII, VI, XII, XVIII.

You may find that the lessons overlap occasionally and it is not impossible that you will find some things you cannot do at all. What of it? The science of botany can never be finished and your teachers are wise enough to know that no person can do all that is suggested. If you work faithfully and intelligently you will accomplish enough and you will not be criticised for not doing the impossible.

Course III

Beginning in the winter and closing in the autumn.

Winter. I, II, III, IV, V, VII, VIII, IX.

Spring. XIX, XX, XXI, XXII, X, XI, XIII.

Summer. XIV, XV, XVII, VI, XII, XVIII.

No matter what course or what arrangement is followed, your plan of study should be to read a lesson through hastily by aid of the studies in order to see what is necessary for you to have or to do in order to master the lesson. It may not be advisable always to follow the order of studies as given in the lessons; this order is best determined after you have looked through the lesson.

It may be desirable to look ahead over several lessons to see what is coming so that you may be watch-

ing for plants and preparing the things that need time to grow or the experiments that need time to mature. For instance, the seeds studied in Lessons I and II must have time to germinate, and many of the experiments given in the earlier lessons will extend over days. If Lesson V comes in the winter or early in the spring you may have to bring small branches into the house and putting them in a vase filled with water, wait for the buds to develop.

Course IV

Beginning in the spring and closing in the winter.

Spring. VIII, IX, XIX, XX, XXI, XXII, X, XI, XIII.

This may be a little difficult because so many terms and names will be new. The student must learn thoroughly the things suggested as reviews in the studies of XIX, XX, XXI, and XXII. By so doing the work is altogether possible for it has been done many times. Parts of these lessons may profitably run over into the summer.

Summer. XIV, XV, XVI, XVII, V, VII.

Autumn. I, II, III, IV, VI, XII, XVIII.

Course V

Beginning in the summer and continuing through the year.

Summer. XIV, XV, XVI, XVII.

Autumn. V, VII, X, XI, XIII.

Winter. I, II, III, IV, VIII, IX.

Spring. XIX, XX, XXI, XXII, VI, XII, XVIII.

This is a very satisfactory arrangement as it enables you to get nicely acquainted with the subject during the summer and to make collections for study in the late autumn and winter.

If you have a smattering of botany or are reviewing it or are well prepared and have abundant time to work, you may be able to make a radically different arrangement for yourself and even to shorten the duration of the course, though the last plan is not recommended. No matter what your preparation has been you can find material for a year's study, and if the course does not prescribe them, you will have discovered lines of independent investigation that will keep you interested.

Remember that if you get into difficulties of any sort the school will take pleasure in replying to your questions and will do all in its power to help you out.

Send to the school at the completion of each lesson your answers to the test questions and such only of the studies as you are specifically directed to send in.

The test questions should be answered without reference to the text-book unless you are told to use it in some special cases. Do not copy the questions but number the answers to correspond with the questions.

If you are unable to answer any question, give the reason under the proper number. When your papers have been read they will be returned to you with full criticisms and corrections, accompanied by the correct answers in print. These will contain much new and helpful matter.

LESSON I

CHAPTERS I—III

STUDIES

A. Read the Introduction thoughtfully. Pages 1–3.

B. Draw a cross and a longitudinal section of a squash, pumpkin or melon seed, a bean and a pea, labeling the parts. Pages 5–9.

C. Record at least two of the experiments on pages 9–13.

D. Send in drawings of cross and longitudinal sections of soaked corn. Page 16.

E. Give an account of your iodine tests for starch. Page 18.

F. Study to the end of Chapter II, page 24. You will probably be unable to do the work in Section 23, page 18; Section 25, page 21; and Experiment X. Read those portions of the text carefully and study the drawings. You will be able to understand them.

G. Send two sets of drawings showing three successive steps in the life history of each of two seedlings grown under your care. See Sections 32–36, pages 25–28.

H. Send tabular view of the experiments you have performed, following the form in Section 46, page 34.

TEST QUESTIONS

Write and send in answers to the following questions. Do not copy the questions, but be careful to

give each required piece of work and to number each answer as the questions are numbered here. If you are unable to answer any question, give the reason for the omission, under the proper number. These are test questions and should be answered without reference to text-book or notes.

1. What is a cotyledon? What are dicotyledonous plants? Name one.

2. What is the function or use of root-hairs?

3. Why is it advantageous to the squash plantlet to have its cotyledons dragged out of the ground rather than pushed out, tips first?

4. What is a cell and what is the all-important part of it?

5. Where is the food of the plantlet stored in a bean, in corn, in a pea?

6. Whence does the germinating plant derive the energy that enables it to push its way through the soil?

7. What is morphology? What is meant by plant ecology?

LESSON II

Chapter IV

STUDIES

In the preparation of this lesson and usually in succeeding ones, it is best first to read through the coarse print of the text and then to return for more particular studies.

A. Sections 48–52 should be carefully read but the student should not rest with this. He should make careful examinations of the roots of many plants. Take such full grown potted plants as you are willing to sacrifice after they have lost their beauty, lay your hand over the top, invert the pot and remove it by lifting it from the earth and roots. The pot will come off easily if you strike it sharply with a stick. Then carefully shake and wash all the dirt from the roots, and estimate the length of the roots and their surface and compare with that of the leaves and branches. Dig up a few of the persistent weeds and study the arrangement and extent of the roots. Find and examine as many as possible of the plants mentioned in the text. Dodder can be found in midsummer in almost any wild lowland of the middle west. You will recognize its most common form as a tangled mass of yellowish threads, bearing inconspicuous white blossoms and clinging to the tops and sides of willows or coarse weeds. Its connection with

the ground was severed early. Sometimes but few of the threads show and there remain rings and cylindrical masses of the blossoms apparently growing out of the stem of the foster-plant.

The *Handbook* mentioned in the text is a laboratory guide too technical for our work.

B. You can not do all the work in Sections 53-56, but by studying the text and figures thoughtfully you can get a clear idea of what the microscope would show. Much of the detail in Section 56 can be made out with your simple microscope. Diluted red ink will answer for eosin, and the experiment with iodine is very easily performed. See page 18.

C. Experiment XV, page 50, is well worth trying, both for the practice it gives and because of the important principles it illustrates. In chipping away the shell from the larger end be careful not to break the inner membrane which must be punctured at the top through the tube.

D. Omit work in fine print on page 53.

E. In Experiments XVII–XIX, pages 55-57, remember that it is not necessary that the apparatus should be exactly as described. If you cannot make it as described, invent some simpler form, being careful to preserve the essential conditions only.

F. Omit Experiment XX, page 59.

G. Be sure to try the experiment described in fine print on page 61.

H. Make and send in the tabular view of the experiments you performed in this lesson. See page 34.

I. Send in the drawings you made in Experiment XVIII, page 56.

J. Describe your Experiment XV, page 50. How much increase was there in the height of the fluid in the tube?

TEST QUESTIONS

1. In what way may a plant be benefited by a poisonous root or by one with a nauseous odor?

2. What are haustoria?

3. Classify roots as to form and give examples from your own observation.

4. What purposes are served by the adventitious roots of the Indian corn?

5. (a) Mention three plants that store food in their roots. (b) How long is each in storing the food? In exhausting it? (c) Classify plants according to the life of their roots.

6. What are root-hairs? Show by diagram their relation to the cells of the epidermis of the root.

7. Refer for a moment to Fig. 27, page 58. What is shown by the tips of the roots on the sprouting peas? Explain fully.

8. What is the use of the corky layer covering the roots?

9. What differences would you expect to find in aerial and water roots?

LESSON III

CHAPTER V AND CHAPTER VI TO SECTION 103

STUDIES

A. Section 77, page 62, contains a very important series of studies. If you cannot procure horse-chestnut twigs you can find branches of the lilac which are nearly as useful for the purpose. Prepare your drawings carefully and send them in with the answers to the questions asked in the section.

B. Make a careful study of the text and illustrations through the remainder of the chapter. It is not difficult and is self-explanatory. When there are references to figures in different parts of the book, be sure to look up the figures and study them. Try to find in nature around you types of the forms described. Keep your eyes open all the time when you are walking and driving, and form the habit of recognizing types and referring forms to the nearest type you have studied.

Fill out the review called for in Section 95, page 82, and send it in with as many illustrative sketches as you can conveniently make.

C. Section 96, page 83, is a simple piece of work that should be done thoroughly. You may not be able to get the palmetto, but you can find rattan and bamboo or a piece of cane. Cat-brier is sometimes called green-brier. Section 100, page 86, should be

worked out and then a comparison made between the two types of stems.

Send in your sketches for these two sections.

D. A comparatively large portion of the laboratory work in Chapter VI, page 83, you will be unable to do, but you can understand the subject pretty well if you will put time enough on the illustrations and the explanatory text.

Section 97, page 84, and Section 101, page 86, are work for the compound microscope. Fig. 53, page 84, is a diagrammatic cross section, that is, it does not show the stem exactly as it appears but merely indicates the relative position of the parts to be considered. The same is true in a sense of Figs. 55 and 56, on page 87, but as diagrams they are really clearer than your microscopic section would be and more intelligible than a section could possibly be to the beginner. Learn the names of the different parts of the stem so that the future text will be intelligible.

E. To understand Fig. 58, page 89, imagine the lower edge of B to be brought down to the upper edge of A, and then that Fig. B is laid at right angles to the vertical A. You then see the top and side of a piece of the stem. Your lens will enable you to detect the different regions but not the cellular structure.

TEST QUESTIONS

1. Upon what does the form of a tree originally depend? What causes tend to modify this form?

2. Why cannot a grown tree rid itself of a crook or curve?

3. What modifications of branches have you noticed? Are the prickles on a rose modified branches? How did you determine?

4. Discuss at length the ways in which plants climb, and use for illustration examples from your own observation.

5. What modifications of stems can you trace to the influence of the soil or climate in which a plant thrives?

6. How can you distinguish roots from underground stems?

7. What are fibro-vascular bundles?

8. In what way is the stiffness of the stem in Fig. 55, page 87, secured?

LESSON IV

CHAPTER VI, SECTION 103, PAGE 90, TO CHAPTER VIII, PAGE 119

STUDIES

A. Omit Section 103, page 90. Study Figs. 59-67 with the accompanying texts. Remember that these are highly magnified sections and represent things quite invisible to the naked eye. Each of these figures showing cells in mass is a representation of the structure of tissues. We can usually recognize the tissues with the naked eye, but the peculiar cell structure that makes them different can be seen only with the microscope.

B. The work prescribed in Section 111 is very interesting and you can and should perform it, comparing what you see with the magnified sections shown in Figs. 71-73. If you cannot get the branches mentioned, find others. Do not be content with the study of two. Get as many varieties as you can obtain and study each. A dozen types are none too many.

C. It should be understood that unless told to the contrary, the student is always expected to master the coarse print of the text. The studies are intended to help him in the difficult places but not specifically to mention everything that must be done. Chapter VII is a very interesting one and the only portions that are at all troublesome are those involving the use of Feh-

ling's solution and nitric acid. These (Experiment XXIV, page 117, and a part of Experiment XXV, page 117) you may omit if necessary.

D. Send in your written account of work in Sections 123, page 114; and 125, page 116, together with a few characteristic sketches.

E. Send in your written notes on Experiments XXI, page 108; XXII, page 111; and XXIII, page 115. The experimental work and actual plant studies are far more valuable to you than the text, if you work intelligently and with persistent care.

TEST QUESTIONS

1. Describe three forms of cells and make diagrams of them.
2. Compare monocolytedonous and dicotyledonous stems in structure and in manner of growth.
3. What is grafting and what is essential to its success?
4. What are knots in wood? How do they originate? What care should be observed in pruning and why?
5. What are the long brown scars or slits seen in the bark of the birch or cherry?
6. Tell the chief use of three of the tissues in the ordinary dicotyledonous stems.
7. Trace the circulation of the fluids in the stem. What purposes are served by the process?
8. What causes the flow of water in the stem?
9. You have probably seen that a farmer will cut

up potatoes and plant the pieces instead of planting the whole tuber. Why does he do this? What is necessary in the piece that it may grow?

10. Where have you already found food to be stored in plants? What parts of the bean, the sweet potato, the onion, the Indian corn, and the Irish potato, furnish food to man?

11. What food products does the plant use?

12. Give an account of the early growth of dicotyledonous stems.

13. Distinguish between herbs, shrubs, and trees.

LESSON V

Chapters VIII, IX and X

STUDIES

A. All the work of these three chapters can and should be done by the student. The studies described in the fine print in Sections 131, page 119; 133, page 121; 135, page 123; and 136, page 125, are important and simple, requiring only persistent care. It is not essential that the plants mentioned should be used; others will answer the purpose, though these are usually the easiest to handle. Do not forget to study the illustrations.

Send in your notes and drawings in Sections 131 and 133. Your notes should be full and your drawings numerous to show the most striking points of your studies, and should be lettered and have sufficient written explanation to make them clear.

B. Send in your studies of a leaf as prescribed in Section 141, page 130.

C. Study the drawings upon pages 131 and 132 until these typical forms are all firmly fixed in your mind, with the right name for each. Gather many leaves and classify each according to outline, tip and margin.

D. Do not neglect the fine print study in Section 142, page 134.

E. Chapter X is entertaining and Experiments

XXVI, page 145, and XXVII, page 148, should be tried with several plants as well as with the one mentioned. These experiments and studies of the plants themselves are the valuable part of the lessons and will prove to be the entertaining portion. One cannot do these things without having his power of observation and his consequent pleasure made much keener and more active.

TEST QUESTIONS

1. Draw three leaves in your possession, and describe the shape, tip and margin of each.
2. Distinguish between netted and parallel veined leaves, and show the relation of each to the number of cotyledons and the structure of the stem.
3. Describe two types of venation and show what purposes are served by each method.
4. What is a pollard? From what does the growth proceed in a pollard?
5. Show how much of the plant in Fig. 82, page 122, has grown since the preceding spring.
6. What relation do the veins bear to the teeth at the margins of a leaf? What are the veins in the leaf? What is their function?
7. What is a compound leaf? Make a sketch of an imaginary thrice-compound leaf.
8. What is a leaf mosaic? Why should leaves arrange themselves in such positions?
9. What is meant by the sleep of leaves?
10. How are leaf movements accomplished?

11. What is meant by the word heliotropism. If the more strongly lighted side of a plant grows more rapidly than the other, what heliotropism results?

12. How would a plant grow if placed on a slowly revolving table before a lighted window?

13. Draw an obovate leaf with serrate margin; an arrow-shaped leaf with wavy margin; a lanceolate leaf with an acute tip.

14. What do you call the first terminal bud that a plant produces?

15. What is the function of the scales, the wool, and the waxy secretions, that are found around and upon buds?

16. What is there peculiar in the habit of the compass plant, and what is accomplished by its peculiarities?

17. Attach three pressed leaves to your paper and describe each.

LESSON VI

Review of the First Ten Chapters

The student has now covered ten chapters, one hundred and fifty pages, and in so doing has studied many different things, has learned many new names, and it is surprising if some of his knowledge is not becoming vague. Accordingly he should review the matter in his text-book, examine anew his notes and drawings, and call to mind his various observations. A review should be quite largely a new view, and accordingly this lesson is arranged on a plan somewhat different from that of the preceding ones. The identical studies may not be possible now, but they are suggestive and should be remembered till the time comes when it is possible to carry them out. If you cannot do these, find others that you can do. You will not be required to perform the impossible.

STUDIES

A. Study the root-hold of plants by pulling up several. This can be measured by tying a string to the plant near its root, passing the string over a fixed pulley, and adding weights to the string.

B. Study again the various food reservoirs you have seen. Find proofs that the food is actually consumed by the plant.

C. Study patches of spreading perennial plants:

grasses, strawberries, raspberries, Canada thistle, "butter and eggs," "bouncing Bet," asparagus, and others. Determine how each propagates itself otherwise than by seeds.

D. Examine various soils under the lens and note the differences in the irregular particles. Each particle of soil is surrounded by a thin film of water which remains after the soil appears to be dry. Notice how root-hairs cling to the soil particles.

E. Keep in mind what you have learned, for use in your observation. Study leaves wherever you find them. Watch plant growth and note the individual habits. Try to give plants the characteristics that belong to them. This you will accomplish by studying plants where nature has placed them. The form of a detached leaf is valueless, but that leaf in its relation to the life and environment of the plant is of the greatest importance. Field studies will become fascinating to you as you learn how to observe intelligently.

F. Recur to your studies in germination. Observe the germination of seeds in nature. If there are maple or elm trees near you, see how nature plants the seeds, how they germinate on the surface, and what their struggles are to obtain a foothold and begin life. It is a good plan to keep your window boxes filled with germinating seeds. When you are through with one kind, put in another. When you find a new seed, plant it and watch it. You will begin to see that plants have as distinct personalities as human beings.

G. Remove the rind from a section of corn stalk

and carefully trace the course of the fibro-vascular bundles through the pith by cutting it away. Are the bundles parallel, at a fixed distance from the rind, the same size throughout?

TEST QUESTIONS

1. What are epiphytes and where do their roots grow?
2. What determines how far roots may spread?
3. Where is the feeding surface of roots?
4. How is the presence of starch detected in plant food?
5. Of what use to the plant is the stored food?
6. How could grafting take place without the aid of man?
7. How does a plant obtain water from the soil? How are plants able to live in dry soil?
8. How do root-hairs differ from the rootlet?
9. What is osmosis? Describe an experiment illustrating it?
10. How can you tell leaves from leaflets; compound leaves from leafy branches?
11. What relations in form and size do leaves bear to the places in which they grow?
12. Sketch a complete leaf and name its parts.
13. What is a tendril? What different parts may be modified into tendrils?
14. What does a seed contain?
15. What is the hilum? What is the micropyle? What is an embryo?

16. What are the parts of a cell?

17. Name two types of stems in flowering plants, point out the differences and give examples of each.

18. How do you know that the sap which nourishes the plant finds its way downward through the bark to the place where it is needed?

LESSON VII

CHAPTERS XI AND XII, PAGES 150 TO 186

STUDIES

A. Read paragraphs 159-161, pages 150–151, and study Fig. 116, remembering how greatly it is magnified. Find two stomata and one hair in Fig. 117 A; six stomata and two hairs in 117 B.

B. Read Sections 164 and 165.

C. Try Experiment XXVIII, page 155.

D. Try Experiment XXIX, page 156.

E. Use your lens in studying the hairs on leaves. You will be interested in the variety of shapes and complexity in form of some that you will find. In fact, you should keep the lens near you in all your studies, and form the habit of using it frequently.

F. Omit Experiments XXX, page 160; XXXI, page 162; and XXXVII, page 175. The remaining experiments in this chapter are interesting and quite easily performed. If the particular plants mentioned are not to be had, others will answer the purpose.

Send in report of any two.

G. The table on page 174 deserves a thoughtful study.

H. Fill out completely the blanks in the review summary in Section 190, page 177. Send in your finished outline.

I. Chapter XII should be studied till it is thoroughly understood.

TEST QUESTIONS

1. What are stomata and what is their function?
2. How do stomata open and close?
3. What is the use of the epidermis of a leaf? Of the hairs?
4. What relation does the location of the stomata in a leaf bear to the manner of the plant's life?
5. Discuss the work of the leaf.
6. What is chlorophyll and what is its function?
7. How much starch can a full-grown squash plant make in a day?
8. In what living organism do plant and animal life seem to meet? Describe its life history.
9. What does the autumnal change of color in leaves indicate?
10. What are the characteristics of living protoplasm?
11. What are palisade cells and why are they so named?
12. What differences have you noticed in the shapes of hairs on leaves?
13. What movements may be noted in the protoplasm of plant cells?

LESSON VIII

CHAPTERS XIII, XIV, XV AND XVI, PAGES 186-216

STUDIES

A. Study Chapter XIII with such care that the names of the different forms of inflorescence will be familiar to you and that each form will come to mind as soon as you hear the name. These names as well as those of the forms of leaves will be in frequent use when you come to study systematic botany. Make an outline of the different forms and keep it for reference. Illustrate each form by a diagram.

B. Chapter XIV has three very clear studies of common flowers. It recommends the careful study of but one. If you can get them all, study them all according to directions, except that you need make drawings and notes on but one and may omit all compound microscope work.

Send in your drawings and notes on one of the flowers. This work should be thoughtfully done and the student should examine and identify the parts of whatever flowers he can find. Skill and accuracy in this work will help in the study of systematic botany, which consists of the identification and classification of plants. In all these studies make constant use of your lens.

C. The study of Chapter XIV has made XV easily understood. This is another chapter with new names

that must be made familiar. Write an outline of the parts of flowers and the forms of the parts and illustrate it with drawings. Carry it about with you, consulting it and comparing it with such flowers as you can obtain to dissect. Study the drawings in the book. In these ways you will get the names thoroughly.

D. From Chapter XVI you will have to omit Experiment XXXVIII, but you will be able to understand the chapter from the text and drawings.

E. Fill out and send in the outline review on page 207, and send in several diagrams of cross and longitudinal sections of flowers. See page 206.

TEST QUESTIONS

1. Distinguish between determinate and indeterminate inflorescence. Examples.
2. Define peduncle, pedicel and scape.
3. Distinguish between corymb and cyme.
4. What is a catkin? Example.
5. What are composite heads? Example.
6. Make diagrams of the cyme, head, compound umbel and raceme.
7. Classify the flower clusters.
8. What are the essential organs of a flower? What the protective organs?
9. When is a flower perfect, complete, regular and symmetrical?
10. What are dicœcious plants? Monœcious plants? What is a pistillate flower?

11. Make and explain diagrams to show the different parts of pistils and stamens.

12. What are diadelphous stamens? When are floral organs said to be adnate? When are petals perigynous? When are stamens hypogynous?

13. What is a bell-shaped corolla? Make a diagram. What indication have you usually on a gamopetalous corolla to show the numerical plan of a flower?

14. What is a flower for? What is the morphology of a flower, that is, to what do the different organs correspond?

15. What is pollen? What is fertilization and how does pollen fertilize an ovary?

LESSON IX

CHAPTERS XVII, XVIII, AND XIX, PAGES 217-234

STUDIES

A. Chapter XVII contains some very interesting studies that are quite easy except for a very little microscopic work. Do not be content to say that you know all about a specimen; if you study it closely you will find out many things you never knew. Do not try to get your information from the book. Get it at first hand. Botany should be a study of plants, not a study about plants. Do not be content with one or two fruits. If you cannot get the ones mentioned in the text, find something else. Send in your notes and sketches of one of the studies.

B. Collect as many "fruits" as you can. Determine what are fruits in the botanical sense and what merely in common speech. Do you find so-called "fruits" that are really seeds? "Seeds" that are really fruits?

C. Complete and send in the outline summary which is begun on page 227. Name an example of each kind of fruit.

D. Chapter XIX is an important one that should be carefully studied as it is descriptive of the basis of

classification. The important data in the chapter are:

a. Idea of Genus.
b. Idea of Species.
c. How plants are named.
d. Idea of Order or Family.
e. Idea of Division.

E. A certain portion of the Table of Classification on pages 232-233 should be thoroughly learned so that the meaning of each term used will be always recognizable. That portion of the table is:

Division I. Cryptogams or Flowerless, spore bearing plants.

1. Group I. Myxothallophytes. Minute unicellular, plasmodial plants; the slime fungi.
2. Group II. Thallophytes. Leafless, cellular cryptogams including bacteria, algæ, fungi and lichens.
3. Group III. Bryophytes. Mosslike plants, including mosses and liverworts.
4. Group IV. Pteridophytes. Fernlike plants, including the ferns, scouring-rush and club mosses.

Division II. Phanerogams or flowering plants, bearing seeds.

Class I. Gymnosperms, such as the pines, cedars and other evergreen trees; ovaries naked, that is, not included in a pistil.

Class II. Angiosperms. Seed plants with closed ovaries including most of what we call flowering plants.

Subclass I. Monocotyledonous plants.

Subclass II. Dicotyledonous plants.

Though the outline may not seem perfectly clear to you, it will do no harm to memorize it now. It will become more real as you proceed with the lessons.

TEST QUESTIONS

1. What is the difference between a fruit and a seed?

2. What is the difference between a follicle and an akene? Between a capsule and a follicle?

3. What are the grains, such as corn and wheat.

4. Explain the strawberry as a fruit; the raspberry; the blackberry. Are they berries as the botanist understands the term? What are grapes, currants, potato balls?

5. Make diagrams to show cross sections of drupe and pome.

6. What are nuts?

7. How are plants named?

8. Where are monocotyledonous plants placed in the system of classification? Where are the true ferns?

9. Of what is a botanical family composed?

10. Upon what is placed the most reliance in classifying plants: root, stem, leaves, flower, or fruit?

11. What are hybrids? Have you ever known or seen examples of hybridization in a garden?

LESSON X

CHAPTER XX, PAGES 235-257

STUDIES

A. In the last lesson we began a study of classification. Our text now proceeds to give us a series of studies on plants representing the different classes. It begins with the lowest in organization, simplest in form, though most difficult to study. The succeeding types are constantly growing more complex in organization and at the same time becoming simpler for our study. Accordingly much of the work suggested in cryptogamic botany is only possible for advanced students who are well supplied with material and suitable apparatus, and have acquired some skill in the use of the compound microscope. But it is worth while to read most of the fine print and to study the drawings. In this lesson most of the space will be taken up in explanations and further descriptions of the types.

B. Sections 258-259, page 235.

Seeds contain embryo plantlets and consist of fertilized ovules. Spores do not. They are simply vital cells which are bred from the parent plant and have the power to reproduce themselves. The two ways in which spores are produced should be noted and the advance references to figures should be looked up.

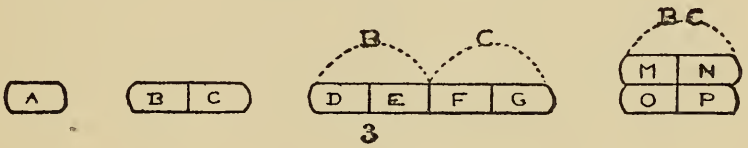
C. If you can find slime mould (Secs. 260-262), spirogyra (Secs. 273-276) or vaucheria (Secs. 281-284) your lens will show you much that is interesting. You will be able to recognize them from the cuts.

D. Bacteria (Secs. 263-266) are very minute, the smallest of living things. Two hundred of them side by side would not measure more than the thickness of writing paper. You cannot study them. They are present almost everywhere in innumerable quantities, and being immersed in the plant or animal in which they thrive, they sometimes multiply with inconceivable rapidity and exhaust the vitality of the tissues upon which they live. They produce decay and are the principal agent by which animal and vegetable forms are converted into soil or gas. Some are beneficial, others intensely destructive. Some are the cause of violent diseases, and others are instrumental in preparing the foods upon which we subsist. Some are in form like short rods which are either straight or spirally coiled, and others are minute globes or spheres. They absorb food throughout their whole body. Bacteria reproduce themselves by fission, each plant becoming two by a division extending through the nucleus.

E. Diatoms (Secs. 270-272) are one-celled plants that may be fixed and may move about. The cell walls become solidified by deposits of silica and are often extremely beautiful in their markings. One view of them shows them to be shaped like an elongated rectangle, while a view at right angles to the

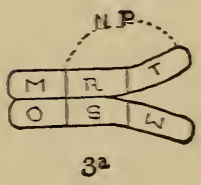
first seems like an elongated oval, a disk, a boat-shaped or an angular structure. To allow for growth one cell wall overlaps the other as does the cover of a box. A high-power microscope is needed to see them. The diatoms are the lowest class of the algæ.

F. The reproduction of spirogyra (Sec. 276) is an interesting topic even though you are unable to see it, as it illustrates both methods of propagation found in algæ. The text gives a clear description. In spyrogyra and the other filamentous algæ the cells do not separate but remain joined together so that as cells divide in parallel lines a long chain of them will result, though each cell is really a separate plant. The division takes place like this : A represents a single cell; B C, the same one grown and divided. When these have grown sufficiently each will divide again making D E F and G. A second plane of division might pass through at right angles to the first in B C and the group would appear as in M N O P.



G. Some of these algæ develop a base and an apex differing from the rest of the filament. The basal cell may become elongated and serve to fix the plant; this is called the rhizoid cell and the remainder of the filament the thallus, terms that correspond somewhat with root and stem among the flowering plants. Growth varies a little and branching results as in

vaucheria (Secs. 281-284). This is easily understood. Referring to the last figure above, imagine N and P to divide and the resulting cells to separate at the horizontal line. The following form would result:



3a

By a similar process branching might extend in other directions. Notice how in vaucheria development has extended still farther and some cells take upon themselves distinct offices and produce the fruiting organs discussed in Section 284.

H. Nitella and chara, one or both of which you may be able to find in ponds, show a still higher development which will be understood if you trace out their formation by means of simple division of cell and the taking on of marked characteristics by different cells.

I. Fucus and nemalion (Secs. 291-295 and 296-304) bring us to the end of the types of algæ. The differentiation in cells has increased till we recognize with the naked eye the function of many. At the growing point the cells seem uniform but the further they are removed from that point the greater the difference and the greater the change in function. The cells of the compact cortex or bark protect the plant and convey food, the bladder cells give buoyancy to the plant when it is submerged. The disk by which it is attached and parts of the stem above are elastic and permit the plant to sway back and forth as the waves pass over it. The "sea weeds" of the genus fucus grow to be very large sometimes and are conspicuous features of every coast.

TEST QUESTIONS

1. To what division of plants do all those studied in this lesson belong? To what group do the slime fungi belong? To what group do the bacteria and the characeæ belong?

2. Are the algæ an important group of plants? Give some idea of their variations in size and form.

3. In what respect does the growth of vaucheria differ from that of spirogyra and the lower types?

4. Give the life history of the vaucheria.

5. What one of the algæ may be considered the highest type of organization? What resemblances in appearance can you trace between this plant and the flowering plants?

6. What are bacteria? How do they reproduce themselves? What are some of their characteristics?

7. What are oscillatoria and where do they live?

LESSON XI

CHAPTER XX (CONCLUDED), CHAPTER XXI IN PART,
PAGES 257-281

STUDIES

A. This lesson includes the study of different types, some of which can be readily obtained. Read carefully what is said in each case about the occurrence of the plant and then search for it. Where you are told how to cultivate a plant proceed to raise it as indicated. You will have no difficulty in securing specimens of mould if you follow directions, Section 306.

B. Fig. 190 should be studied thoughtfully. Find the hyphæ in Fig. 189. Now imagine ten of these much magnified to be in conjugation at 1, Fig. 190. In 2, see the partitions forming across the hyphæ between *b* and *a*. These two *a's* continue to grow and to change appearance till in 3 they become granular in appearance. In 4, at *b* the zygospore is complete and ready to germinate. The process of germination is shown in 5. The globe at the top is a spore case which when mature will burst, discharging spores; these will germinate and produce plants like Fig. 189, which in turn will grow zygospores: so the circuit of life or alternation of generations is completed.

C. The cluster-cup stage of wheat rust (Sec. 311) is about all you can make out with your lens, but that will prove interesting.

D. You will not be expected to accomplish much in the study of microsphera (Secs. 314-315) but you can find agaricus (Secs. 316-319) and make out a great deal with your lens. Do not try experiments in eating mushrooms, for some of the poisonous ones imitate their harmless relatives very closely to the untrained eye.

E. Study the yeast plant as in Section 320 and perform Experiment XXXIX. Send in an account of this experiment, page 268. Omitting Section 321 you will find the rest of the fine print description of yeast to be interesting.

F. Omit the work on Physcia but read Sections 327-329.

G. The coarse print in the remainder of the chapter is the summing up of what you have done. See that you comprehend it all.

H. Marchantia (Sec. 335) grows almost everywhere in damp shaded places. It forms broad green mats that, unless the winters are very severe, are practically evergreen. Figs. 201 and 202 give a good idea of its shape, the thallus lying close to the ground or against the rocks. It is dark green with lighter shades, and its little umbrella-like receptacles about two inches high make it very easy to identify. It is one of the finest of the lower cryptogams for study and you can make out everything but its cellular structure by the aid of your lens.

The growing point is the little depressed spot at the tip of the thallus. The rhizoids are the root-like objects on the lower side of the thallus. What is their func-

tion? The dot-like circle in the middle of the diamond-shaped area is a stoma. Notice the midrib. The two receptacles are easily distinguished but you cannot hope to make out the minute fruiting parts. Your work is outlined in Sections 336, 338, and 339. The antheridia are shown in Fig. 203. You must imagine that each sperm cell as it falls from the receptacle into the dew or water becomes a very lively body moving about by two long cilia attached to its end. Eventually some one of these cells finds its way to the archegonia which hang among the delicate fringes suspended from the underside of the other receptacle as shown in Fig. 205. From these fertilized cells develop the spores that reproduce the plant. Look for the buds (gemmæ) enclosed in cup-like receptacles on the thallus. These are not always present but you cannot mistake them when found. When these minute buds are mature and are rolled out upon the ground they begin to grow, one side developing rhizoids and the other the upper surface of a thallus. Search for marchantia and when you have found it work it all over with your hand lens. It is a most fascinating specimen. In the explanation of Figs. 201 and 202 the words "male" and "female" should be transposed. The word is right in Fig. 205. Send in an account of your study on marchantia with sketches.

TEST QUESTIONS

1. What are zygospores?

2. What is a saprophyte? How is yeast determined to be a saprophyte?

3. What is symbiosis? Mention plants in which this habit is manifest.

4. Trace the relationship in classification between mould and yeast, and the liverwort as typified in marchantia.

5. Give a connected account of your study of mushrooms.

6. What is meant by the "rising" of bread? How do yeast plants assist in this?

7. (a) The yeast plant reproduces itself by budding; the marchantia forms buds or gemmæ; are these alike? Are they like the buds of flowering plants? (b) How does the budding of yeast differ from fission in some of the algae?

8. Why is rust injurious to wheat?

9. Why should the farmer be suspicious of barberry bushes near his wheat field?

LESSON XII

Review

STUDIES

A. Though we have not completed our studies among the cryptogams, it seems wise before we go any further to stop and review our work. This should be done by going over our notes and sketches and the papers we have sent in, not reading everything but seeing that we can recall what we studied. The drawings in the book will often suggest the text matter. If we find we cannot remember what they are about we should look up the text.

B. This is a good time to go over faithfully all the matter that is contained in the answers. Much of it is matter that is not in your text-book but was sent to supplement the text and to clear up the points that might be obscure to you.

C. See if you are familiar with the scientific terms that have been introduced to you. You can pick them up rapidly by turning the leaves of your book for they are printed in *italics* the first time they appear. The scientific names of plants are also printed in *italics* in your text.

D. Turn to your table of contents and look at the headings of the chapters. See how long you could talk on one of these headings if given it as a topic.

E. Find out all you can on the following topics, using the index of your book (page 397) whenever it is helpful:

Dependent plants.
Single-celled plants.
The movements of plants.
Reproduction of plants.
How the seedling grows.
How water moves in plants.
How plants breathe.
How plants keep their form.
Starch, where it is found and how it is made.
The algae and how they live.

F. Now take one of these topics or a similar one which you may prefer, work it up from your text, encyclopedia, or any other authority you can find, and prepare and send in a paper or essay of at least three hundred words on the topic you have chosen.

TEST QUESTIONS

1. What is meant by alternation of generations? Illustrate.
2. What are lichens, where do they live, and how do they propagate?
3. Make an outline showing the principal facts in the form and life of the marchantia.
4. What influence has the attraction of the earth on the growth of a plant?
5. How could you prove that starch is formed only

in the green parts of plants, and under the influence of light? Describe experiments.

6. Are fibro-vascular bundles found in any of the plants from the lowest up to and including the marchantia?

7. Contrast determinate and indeterminate inflorescence.

8. If you find two phanerogams and the leaves of one are parallel veined and those of the other are netted veined, what other differences may you expect to find in the plants?

9. Imagine a flower that has five lanceolate sepals; four ovate petals; six stamens, two short and four long; and a single pistil containing a two-celled ovary. Describe the flower in four general words and explain what each means.

10. Give in outline form the different methods of reproduction which you have studied in plants.

LESSON XIII

CHAPTER XXI (CONCLUDED) AND CHAPTER XXXII
PAGES 281-297

STUDIES

A. We now enter upon the study of plants which are more easily procured and are so large and highly developed that it will be a greater pleasure to study them. Mosses are available almost anywhere and can be collected with very little trouble. Follow closely the directions for the study of a moss, and do not be content till you have made out the parts and have answered to your own satisfaction all the questions. These particular studies are in Sections 343, 344, and 346. Sections 345 and 347 are for reading. The basket-shaped enlargements alluded to in Section 344 are the receptacles of the antheridia or male cells. In some species of moss this receptacle is terminal; in others the stem grows on after the antheridia have escaped. When the lid of the capsule containing the archegonia is removed notice the minute delicate teeth that close the opening. They respond very readily to moisture, swelling up and closing the opening so that the spores rarely escape all at once.

Notice the way in which the leaves contract when dry and cover up the green chlorophyll cells.

B. When we take up the study of a fern (Chapter XXII) we have moved up into another group, the one lying next to the flowering plants. Here again your studies of the plant will be found very satisfactory with only your lens to aid your eyes, unless the contrary is stated in the text. Figure 210 shows you the particular fern whose study is prescribed in the text. If you cannot get this to work upon take another. It may not be like this in detail, but if you follow the method in Sections 349-351 you will discover the differences and your work will be even more valuable. Do not be content with one fern—try several, many, and compare them. Do not spend much time in trying to study the prothallia unless you have access to a greenhouse.

Send in a general account of your studies in ferns, and sketches and notes on one species.

C. You will be interested in looking for club mosses (Secs. 357-358) and in studying them. They are sometimes called ground pine and the long trailing plant is much used for Christmas wreaths and decorations. The cut in the book (Fig. 212, page 292) shows a portion of this with two upright fertile branches.

D. You should have no difficulty in finding some species of scouring-rush or horsetail, or joint grass, and the study in Sections 359-365 should be carefully made. Sections 363 and 365 are for reading. The action of the elaters mentioned in Section 364 can be noticed with the naked eye and seen quite plainly with your lens.

Other species of equisetum differing considerably in appearance can be found later in the season, some in swampy places and others in shaded damp woods and still others on dry hillsides.

Send in your sketches and notes on the horsetail.

TEST QUESTIONS

1. Give the life history of a moss.
2. Why should ferns and mosses be put into different groups of plants?
3. Make a descriptive outline showing the parts of a fern and their function in the different stages of its life.
4. Arrange in order of the natural classification: ferns, bacteria, marchantia, algae, rusts, true mosses, yeasts, club mosses, and slime fungi.
5. What do you know of the habitat of ferns?
6. What does geology show of the life of ferns?
7. In what two important respects do ferns resemble flowering plants in structure and in function of their leaves?
8. What is the use of the silica in the stems of the horsetails?

LESSON XIV

CHAPTERS XXIII AND XXIV, PAGES 298-323

STUDIES

A. Chapter XXIII leaves the close study of plants and leads us to reason over what we have seen and learned and to draw some interesting conclusions. The chapter should be read faithfully even though it does use scientific terms rather freely. They are already familiar to us, are self-explanatory, or their meaning may be found through the index.

The law of biogenesis and its application to animal and plant life is, perhaps, the most important fact of the chapter.

The fact that there is an alternation of generations in flowering plants should be realized and understood even though it is not susceptible of proof to us without more aids than we have.

With this chapter we leave classification based upon structural relationships for a time.

B. Chapter XXIV begins a new department for us though we are familiar already with many of its facts. Do not be content to read about plant societies and plant colonies (Secs. 378-381). Go to some wild tract with which you are familiar and study the societies and the colonies there. It is not necessary that you should know the names of the plants. Learn

to recognize them growing. Then go to another region different in character; as, if the first one was a dry rocky hillside, go next to a sandy plain, a damp shaded ravine or a marshy tract. Study the societies and colonies in the new places. Try to get general impressions.

Send in a brief account of your expeditions.

C. Try to classify ecologically the plants you meet. Again it is not necessary to know the names. Say, "This plant is a mesophyte, that is a tropophyte, and I know it because . . ." (here run over to yourself the reasons for your classification). Try to form the habit of thinking whenever and wherever you see a plant, what its nature is. It will not be long before you make the classification without much effort and almost unconsciously, as you will find out sometime afterward when your attention is called to the matter.

Ecological study should take you out of doors among the plants, where aided by your own good eyes and the facts we have been learning you can find new pleasures every day. The plants will become your friends and you will never cease to wonder at their marvelous adaptations and almost reasoning habits. If you remain indoors and try to get all your knowledge from books you will find even though you can answer the questions asked, that you have little real living knowledge and have lost the most inspiring part of botany.

D. If plants with which you are unfamiliar are mentioned in the text you can often find pictures of them in a dictionary or an encyclopedia, both of

which you should frequently consult if you have access to them.

TEST QUESTIONS

1. What were probably the first plants on the earth's surface? Give reasons for your answer.

2. Give the law of biogenesis and illustrate it.

3. What is the water-fern and what does it show in the evolution of plants?

4. What in flowering plants corresponds to the prothallium of ferns?

5. What is the highest subclass of flowering plants?

6. What is meant by saying that a family of plants is old? Which is the older, the willow or the maidenhair fern?

7. What are xerophytes and what are some of the peculiarities of structure that enable them to live as they do?

8. What class of plants predominates along the seaboard? What class is characteristic of temperate regions? What class is entirely perennials?

9. Distinguish between plant societies and plant colonies. Which will tend to break up? Why?

LESSON XV

CHAPTERS XXV, XXVI, AND XXVII, PAGES 324-352

STUDIES

A. In your study of Chapter XXV go to your physical geography and examine the plant life of the different zones as given there. It will mean more now than it did when you first studied it. If you do not have a physical geography you can probably find some account in your common school books.

B. Draw an outline map of North America locating the principal mountain ranges, river systems, and lakes. Mark the boundaries of the United States. On this general map locate the different plant zones. In the United States color differently or mark out the great floral regions, naming each. Send in your map.

C. While Chapters XXVI and XXVII are somewhat in the nature of reviews and state the facts clearly and plainly, yet you should not be content with the reading. Study all the plants you can find for evidence of their mode of life in relation to other plants, and particularly how they protect themselves. You can doubtless find protective apparatus on plants not spoken of and possibly some protective devices not mentioned.

TEST QUESTIONS

1. Compare the vegetation of mountain heights with that of their bases.

2. What causes tend to make the difference?

3. What devices do plants partially submerged in water use to obtain a supply of nitrogen? How does red-clover supply itself with nitrogen?

4. What is plankton? What is the Sargasso sea?

5. Classify the means by which plants protect themselves from animals.

6. What is the usual relation between the animal and the vegetable world? What exceptions can you mention?

7. What are half-parasites and how may they be recognized?

8. What is the tendency of parasitism?

9. Describe two processes by which carnivorous plants seize their prey. Make sketches.

LESSON XVI

CHAPTER XXVIII, PAGES 353-372

STUDIES

A. No more wonderful studies are offered in nature than those in the ecology of flowers. When you have read this Chapter XXVIII you will be almost incredulous of the statements made, but if you will study the flowers as you find them your incredulity will give place to belief, but you will wonder more and more. You cannot "get your lesson" this time in a day or a week. The one chapter opens outlines of investigation that could occupy you for years, but every investigation you make will pay for itself. Make it a point to examine every flower you can, after the manner indicated in the questions following, using your lens and dissecting needles. Do not expect to receive answers to all your questions. Do not be discouraged if you can find positive answers to none of them. You are learning to see and to reason. One flower will rarely tell the story of its class; you must have many in different stages of growth.

I. Pollination.

1. Is it possible for this flower to fertilize itself? Why? Is it because of the shape or relative position of the stamens and pistils? Is it because of the character of the pollen?

2. If self-pollination is impossible by what means could the flower be fertilized? Could water carry the pollen? Could large insects or birds carry it? Could small insects carry it?
3. What attractions in the way of food does the flower offer to bird or insect?
4. How does it attract the attention of bird or insect? When it has attracted the attention of the animal how does the flower lead its visitor to the food store?
5. When the insect or bird is induced to rifle the nectar or other food by what arrangements of stamens, pistils, or pollen is cross-fertilization secured?

II. Protection of Pollen.

1. What means does the flower take to protect its pollen from wind or rain? What is the position of the flower and the position of its parts in rain and in sun?
2. What precautions has it taken against the intrusion of unwelcome insects?

These are but a few of the questions you will find yourself asking the flowers. Write out and send in a brief account of your studies and show by drawings, when possible, the discoveries you have made. Not less than twenty-five flowers should be examined before this lesson is well prepared. It is not necessary to know the names in order to study the flowers: no introductions are necessary in floral society.

B. Probably the most marvelous adaptations for cross-fertilization are to be found in the orchids, a large family of monocotyledons. They are most common in tropical climates where the greater number of them are epiphytes. They are very irregular in shape, brilliant in color and remarkable for their fragrance. There are many species in our region, the lady's-slipper or moccasin flower being, perhaps, the most familiar. If you can find lady's-slippers you should not fail to study them. Where is the pistil? Where the stamen? How can an insect enter a flower? Where could he crawl out if once in? Which (stamen or pistil) would he pass first going in? Coming out? How is the pollen arranged? What is it like? How would it become fastened to the insect? Do not confuse the stigma with the flat shield which partially fills the mouth of the slipper. The stigma is below this. The stamens and pistil are united and there are two pollen masses.

TEST QUESTIONS

1. Classify the different ways in which pollen (or spores) may be distributed.
2. In what ways do flowers advertise to birds and insects the presence of nectar?
3. Which plants will produce most pollen, dicœcious or perfect flowers? Why?
4. What peculiarities would you expect the stigmas of wind-pollinated flowers to show?
5. Why should the flowers of wind-pollinated plants be inconspicuous?

6. Why are there bright colored stripes on the corollas of some flowers?

7. What is honey?

8. How are ants and other insects too small to effect pollination kept away from some flowers?

9. What are dimorphous flowers?

LESSON XVII

CHAPTERS XXIX AND XXX, PAGES 373-395

STUDIES

A. Chapter XXIX is another that indicates a large amount of very interesting field work which should by no means be neglected. In all your walks consider how plants propagate. Does any plant do it in more than one way? If so, how many and what?

B. Make collections of all the kinds of seeds and fruits you can find and study each with reference to its dispersal. Group those which are dispersed in similar ways and note which have succeeded in developing the most successful modification of the method. Names are again unnecessary. Make and send in a table which shall show each method you have found, the number of species in which each method was used, and the notable variations in each method. Accompany your table with sketches of different types.

C. Keep your eyes open for seeds and fruits scattered or hidden away from the place where they were grown and try to account for their presence.

D. Can you find provisions for making the seed fall in the right position? Can you find provisions for making the seed enter the soil when it has fallen?

E. Watch seeds of trees and other plants to see whether they germinate as soon as they fall, or lie dormant till another season. If the latter, can you detect any provisions for securing their safety during the winter or resting spell?

F. Make special study of each of the unanswered questions and of the experiment in Chapter XXIX. Send in an account with sketches of any interesting or remarkable discoveries you have made in these questions or in the studies mentioned above.

G. Weeds are among the most interesting of plants to the botanist. Do not fail to study as many species as you can find, for each represents a most vigorous, powerful plant, one that has made the best possible use of its opportunities for development. Much as you may detest them in your garden you cannot but admire the way in which they prosper. The dandelion in your closely cropped lawn does not look much like the luxuriant one in the shaded fence corner, but it persists in putting forth its leaves, it cheerfully shortens its scape, it becomes so compact as to pass safely under your lawn mower and then ripens its seeds and proceeds smilingly to crowd out the blue grass you are trying to preserve. You will find many instances of this ready adaptability among the weeds.

H. Be sure you understand thoroughly what is meant by development, by variation, by evolution, by the survival of the fittest, by natural selection. They are terms that describe the forces that rule the living world, plants and animals alike.

I. Look for examples of plant competition and

then watch the progress of the struggle from day to day, from month to month. Do the fittest survive? Try to account for the forces at work. Question yourself and the plants.

TEST QUESTIONS

1. Describe how some tree that you know has struggled with its fellows and how it has succeeded.
2. What tendencies can you see that lead plants of the same kind to vary?
3. Describe some bur that is familiar to you.
4. What purpose is served by the peculiarities of the "tumbleweed"?
5. What advantage is it to the orange to have bitter seeds?
6. Mention five causes that may tend to reduce the number of plants maturing from any crop of seeds.
7. Why are so many species of plants found in the railroad lands fenced in along the tracks?
8. What is meant by the phrase, natural selection?
9. What differences would you expect to find between the bushes at the edge of the thicket and those within it?

LESSON XVIII

Review

STUDIES

A. A general review of the work we have had will now be profitable. It is not wise to make this a mere re-reading of our text. It should include also a thorough study of our notes and of the answers to the test questions.

B. On page XI of Bergen is a list of the full page plates. Look these plates up one after another and see how much more they mean to you now than they did when you first saw them. Here are some questions that will suggest ways to think about pictures:

Plate I, page 76. What evidence have you of a struggle for existence? How are the plants adapting themselves to their environment? To what class of plants do these belong?

Plate II, page 128. To what kind of a plant colony do these belong? How did the willows overcome the loss of their tops?

Plate III, page 140. Are these leaves netted or parallel veined? Is the plant an endogen or an exogen? What words will describe the shape of these leaves? By what modification of the petioles have the leaves been enabled to arrange themselves in this mosaic?

Plate IV, page 158. What is it that hangs from the limbs of the cypress? What kind of a plant is it? To what class of plants does the cypress belong? Would you think that the "moss" belongs to the same colony? Why?

Plate V, page 168. What evidence have you in the appearance of the Indian pipe that it is a saprophyte? Is it a sun-loving plant? Does it manufacture its own starch? Is it an endogenous plant? You can tell positively. Study the flower that has its face turned toward you. Why do the flowers hang downward? Describe the leaves of the trailing plant. What means of defense has it?

Fig. 222, page 315. What are the round-ovate bodies, stems or leaves? Why are they so large, so thick and fleshy?

Plate VII, page 316. Would you expect the leaves of the few plants here to have a thin epidermis? Why should they have narrow and small leaves? To what kind of a colony do these plants belong?

Plate VIII, page 334. How happens it that trees grow along the streams and not on the hill sides? In what zone of vegetation is this scene located? In which of the plant regions of the United States?

Plate IX, page 336. Describe the struggle for existence you can see here. How does the mistletoe cling to the branches of the cottonwood? How do you suppose it originally came upon the cottonwood?

Plate X, page 362. Why has this flower a large brilliant corolla? Why do you think the flowers group themselves together? How have humming-

birds been affected by seeking their food in the depths of flowers? Can the bird be of any service to these flowers? Assuming that he goes from this plant to another of the same species do you think he would of necessity insure cross-fertilization? How have the wings of birds been affected by their habits of feeding?

C. Some topics that are worth looking up are:

(a) The relation plants bear to the formation of soil.

(b) Different forms in the floral envelopes of flowering plants.

(c) Various mechanisms by which flowering plants throw their ripened seeds.

(d) Dependent plants.

(e) A comparison between a fern and a flowering plant.

(f) Comparisons between homologous parts of flowers.

It is not expected that you will work out all these topics in detail, but some of them you can, and you should send in a report on one of them illustrating it with sketches if possible.

TEST QUESTIONS

1. What are cleistogamous flowers?
2. What is the protonema in mosses, and what is its function?
3. What is vernation?
4. Where does the bean store its food for the germinating plantlet?

5. Mention a bryophyte, a pteridophyte, a thallophyte.

6. To what class do yeast plants belong? What is their method of reproduction?

7. Define legume, winged fruit and stone fruit. Illustrate your definition by sketches.

8. What are stomata and what is their function?

9. What is meant by dehiscence? Distinguish between the words pollination and fertilization?

10. What is a cabbage and how does it differ from a bud?

SYSTEMATIC BOTANY

LESSON XIX

SYSTEMATIC BOTANY

Key and Flora

STUDIES

A. Heretofore we have been dealing with the various departments of botany that required little or no knowledge of classification or nomenclature. Henceforth we confine our attention to the common flowering plants and to a study of their classification including their names and relationships. This lesson is introductory to the general subject of the classification of plants.

B. Return to your general classification on pages 232 and 233 of the *Foundations of Botany* and observe that our studies are now to be confined to Division II (page 233) of the vegetable kingdom and that this Division has two classes, Class I-Gymnosperms and Class II-Angiosperms. The latter is divided into two subclasses, I, Monocotyledonous plants and II, Dicotyledonous plants. Get this classification thoroughly in mind so that its names mean something. Whenever you are in doubt about the meaning of any technical terms used in the *Foundations of Botany* consult the index to Parts I and II to be found on pages 397-412. This will refer you to the pages where the terms are explained.

C. Now turn to pages 228-231 and study again paragraphs 249-254. This will make clear to you what is meant by a system of classification. We might make a scheme to show how a single plant stands. I have in mind the common Johnny-jump-up or lady's delight, the small flowered variety of the pansy that is often found growing persistently in old gardens. This plant belongs to

Division II. Phanerogamous Plants, because it is a flowering or seed bearing plant.

Class II. Angiosperms, because it has a closed ovary.

Subclass II. Dicotyledons, because its embryo has two leaves.

Order (Family) Violaceæ. Violet family.

Genus. *Viola.*

Species. *V. Tricolor L.*

and

Variety

Arvensis.

The botanical name of the plant is *Viola Tricolor L. var. arvensis.* The L. indicates that Linnæus named the plant.

D. Now that we have a clear idea of what is meant by classification and the field of our future studies, we will turn to the *Key and Flora* following the index to the *Foundations of Botany.* Flora is a word that has two meanings. It may mean collectively all the plants that grow in a certain region, as the flora of Illinois; it may also mean a book giving a list and description of the plants growing in any given locality.

The title page shows to what locality this *Flora* is restricted.

E. Read the Preface and note these facts: This *Flora* is restricted in locality and also to the *spring-flowering* plants and to commoner ones of those. So in your collecting trips you will find plants not described herein. Usually you will be able to determine the family, frequently the genus, if you cannot the species. If you wish to make a complete study of the flora of this region you must get Gray's *Manual of Botany* (American Book Company). This is a large book and quite technical so that the *Key* is rather difficult to handle and the descriptions difficult to understand at first. The *Manual* contains no cultivated plants. A simpler book that has both wild and cultivated plants is the *Field, Forest and Garden Botany* (Bailey's revision of Gray) published by the American Book Company. This is not restricted to any season, it has a clear and comprehensive key, and simpler descriptions. It does not, however, give all the species of wildflowers. Our *Flora*, however, is sufficiently comprehensive for our purpose and if you learn to use it skilfully you will be able to take up the more difficult texts with comparative ease if you wish to carry your studies further.

F. For the present we will pass on to page 13 and examine the *Flora* as a whole. The plant descriptions run to page 237. This gives 225 pages for plant descriptions exclusively. The descriptions begin with Class I, Gymnosperms. Study the definition and examine Fig. 1, page 15 till you understand it.

In the definition you find a new word *carpellary*. Turn to your *Glossary* (page 239) and see what it means. Its definition is "relating to a carpel." What is a carpel? This glossary does not tell, because the word *carpel* was used in the *Foundations of Botany* and explained there. If you have forgotten it turn to the index of *Foundations* and find *Carpel 198*. On page 198 is the definition "a one- or many-seeded pistil." So the gymnosperms have no pistils, but scales that somewhat resemble pistils.

G. The plants are arranged in the *Flora* according to their relationships so that we know we shall find all the gymnosperms together. Turning over the pages we find that Class I ends on page 19, and Class II, Angiosperms, begins on page 20. Class I is comparatively a small one, then. There is in it but one family, the *Coniferæ* or Pine Family (page 13). *Coniferæ* means cone-bearing. This family has eight genera. 1. Pinus (page 14). 2. Picea (page 16), etc., and each genus has one or more species.

A tabular outline of the Gymnosperms in our *Flora* would begin as is shown on the following page:

I. Phanerogams.
Class I. Gymnosperms.
Order I. Coniferæ. Pine Family.
Genus I. *Pinus*, *Tourn.* Pines.
Species 1. *P. Strobus*, *L.* White Pine.
2. *P. Tæda*, *L.* Lobolly Pine.
3. *P. rigida*, *Mill.* Northern Pitch Pine.
4. *P. inops*, *Ait.* Scrub Pine.
5. *P. sylvestris*, *L.* Scotch Pine.
6. *P. resinosa*, *Ait.* Norway Pine.
7. *P. palustris*, *Mill.* Long-leaved Pine.
Genus II. *Picea*, *Link.* Spruces.
Species 1. *P. nigra*, *Link.* Black Spruce.
2. *P. rubra*, *Dietrich.* Red Spruce.
Etc., etc.

H. Class II, the Angiosperms, begins on page 20. Learn the definition. Subclass I, Monocotyledonous Plants, is placed first. Learn the definition for this subclass. Be sure you know the exact meaning of every term used. Next are printed the various families of the monocotyledons, those naturally most nearly related being placed as near together as possible.

They are: 2. Typhaceæ. Cat Tail Family, page 20. You remember Pinus was the first family. 3. Alismaceæ. Water-Plantain Family, page 21, and so on, till we reach page 46 when we find ourselves at the end of the monocotyledons.

I. On page 47 begins Subclass II, Dicotyledonous Plants. Learn carefully the definition of dicotyledons, being certain of every term. The numerous families of dicotyledons take up the remainder of the *Flora*.

TEST QUESTIONS

These test questions are inserted here to see if you clearly understand what is meant by classification and what the *Flora* contains. So use your text-book if necessary in preparing your answers.

1. Complete the outlines of the gymnospermous plants in the *Flora*. How many and what families are shown in the gymnosperms? How many genera and how many species of plants in the Coniferæ?

2. How many and what genera in the Betulaceæ? (Use index of *Flora*.) To what division, class and subclass do the Betulaceæ belong?

3. What is the common name of *Nymphæa odorata*, *Ait.?* (Use index.) To what family does it belong?

4. What is the botanical name of the trumpet creeper? Has it an exogenous stem? Has it parallel veined leaves?

5. Give names of what seems to you one of the most important of the dicotyledonous families. Why did you select it?

6. Find the name of a common plant which you know and give its classification as it appears by its position in the *Flora*.

7. What is the meaning of the word pappus?

8. What is meant by pileus? How did you find out?

LESSON XX

Key and Flora

STUDIES

A. The way we studied the *Flora* in the last lesson would not teach us much botany, but it has shown us what the *Flora* contains and one way of using it. Another and important use is, that it will give us the name of a plant we do not know. To teach you so to use it is the purpose of this lesson.

B. To begin with we enter the *Flora* by means of a *Key to the Families*. This key is printed on pages 5 to 12. Begin your study by reading *How to Use the Key and Flora*, pages 3-4.

C. Now, let us examine the *Key*. In this key are grouped all the families shown in the book. They are classified, not always naturally now, but artificially by their most striking characteristics. First they are grouped in the two Classes I and II. Then Class II is grouped in its two Subclasses, Monocotyledons (page 5) and Dicotyledons (page 6). The Dicotyledons are grouped in three divisions, I, Apetalous (page 6), II, Polypetalous (page 7), and III, Gamopetalous (page 10). The Apetalous Division has two groups A and B (page 6). The Polypetalous Division has two groups, A (page 7) and B (page 8). Now observe that under

each of these divisions the families are grouped, their names appearing to the right of the page, preceded by the number of the family as it appears in the *Flora* and followed by the page on which the family appears. Now examine one of these groups. Take the one labeled A, page 6, a group under the Apetalous Division of Dicotyledons. The first line defines the group—"Flowers monœcious or dicœcious, one or both sorts in catkins." Notice the next line is indented, that is, is thrown a little to the right. Three lines below, another is indented just the same distance. That shows the two divisions of A, 1, "*Staminate* flowers in Catkins, the pistillate ones solitary or clustered" and 2, "*Both* kinds of flowers in Catkins." Under the first division are but two families, one with "leaves pinnately compound" (the Walnut), the other with "leaves simple" (the Beech). But the second division has two sections shown by indentation, one with "leaves alternate" under which are four families, the other with "leaves opposite" which has but one family.

Study the *Key* carefully till you understand its plan. Remember that different groups are shown by the relative indentation of the lines.

D. Now suppose we have a flower, the Johnny-jump-up, but we do not know its name. We examine it carefully. It is not from a cone-bearing tree, so it is an angiosperm. The leaves are netted-veined and the parts of the flower are in fives, so we know it to be a dicotyledon. This carries us to Subclass II, page 6 of the *Key*. Now we must decide where it

belongs in this group. Both calyx and corolla are present and the petals are separate—so we know it is in the Polypetalous Division and that brings us to the bottom of page 7. Now is it in Group A or B of this division? That depends upon the number of stamens. Group A has more than ten; Group B not more than ten stamens.

This flower has five stamens, so it belongs to Group B, page 8. The first division here is "Trees, shrubs, etc.," and the second (middle of page 9) is "Herbs." Our plant is certainly a little herb, so we move on to the middle of page 9. How many ovaries has our flower? One single-celled ovary. So we will remain in the first section under "Herbs." The corolla is very irregular. So we run down the page ten lines till we come to "Corolla irregular." Here are two classes —"fruit a legume" and "fruit a capsule." Our plant has a capsule. There are two of these families having capsules and as our flower has five stamens we know it belongs to 66 Violet Family, page 149.

E. We have partially identified our flower. We know its family. Now we will turn to page 149 and read the description of Violaceæ. Our plant answers it, as we knew it would. Turning over the leaves we see there is but one genus given in the family and so we read what is said of Viola. Our flower answers the description perfectly and we know we have half its name. It is of the genus Viola. Pages 150 and 151 show us that Viola is composed of Section 1, Section 2 and Section 3. Our flower has a stem so it cannot be in Section 1. It is not from exactly a peren-

nial root, we think, and it has very large stipules so we will try Section 3. It cannot be *V. tricolor* for our flower is so little. Then it must be *V. tricolor var. arvensis* for we remember that we found it in an old deserted garden and it probably is not a native.

Now this is the process by which we identify strange flowers. Sometimes it is a much simpler, sometimes a longer process. Study the method above till you thoroughly understand it. If you can get pansies and violets of different species, run them through in the same way, going to the plant to get the answers to the questions. You may have some trouble at first but skill will come as you continue to work. It is a good idea to work for a while with flowers that you know. Send in an account of one or two flowers you have traced and let us know how you are succeeding.

F. You may run into a family like the Cruciferae, page 93. Here there are so many genera so nearly alike that you are given a little key to the genera. It is on the same plan as the key to the families, and you can use it in the same way. The Roman numerals here indicate the number of the genus. "Capsella, IX" in the second line of "A" shows you that you must turn to the ninth genus which you will find at the top of page 98. There you will see the complete description. In case your plant goes to a family having several genera with no key, read each genus-description till you find the right one. This is the course to take in determining species also.

TEST QUESTIONS

These test questions are given to see if you need more help on your study of the *Key*. Use the book in answering.

1. Here is a description of a flower. Find its family by way of the *Key:*

The flowers of this herb are separate and in umbels and are not enclosed by chaffy bracts. The perianth is free from the ovary and has three green sepals and three beautiful blue petals which soon disappear. There is but one style and but one stigma and the seeds have but one cotyledon. The leaves are parallel veined.

2. From these additional facts verify the description of the family when you have found it:

"Leaves very narrow, a foot or more long, linear and keeled, often purple veined, tapering to point, entire, sheathing at base. Leaves and stem succulent, with mucilage-like juice.

Flowers are from two to many; in terminal, sessile umbels; perfect regular, 1 inch broad. The sepals remain persistent on the plant. Petals fall off, or liquefy.

Stamens about 6—sometimes with three shorter than the others, filaments beautifully densely bearded.

Ovary 3-celled with 2 ovules in each cell. Pedicels recurved in fruit. Capsule ovoid or oblong 3-celled, 3-valved, 3-6 seeded.

Stem erect, stout, smooth or hairy, 1 or 2 feet high. Grows in dry sandy soil."

3. From the same description determine the species. Write the full name and the classification.

4. In the *Key* what two families are grouped under the alternate leaved section of those gamopetalous herbs whose ovaries are not adnate to the calyx, whose flowers are regular, whose ovary is one-celled and fruit a capsule?

5. What distinguishes the two families from each other in the *Key?*

6. Define gamopetalous, apetalous, terrestrial, adnate, hypogynous.

LESSON XXI

Key and Flora

STUDIES

A. The two preceding lessons have shown what the *Key and Flora* are and how they may be used. Another lesson seems necessary. The chief difficulties you will experience are these:

(a) An unfamiliarity with the terms used. Many are new, others have not been clearly mastered before. Use the glossary and the text of *Foundations*.

(b) Uncertainty and errors in your examinations of plants. This is particularly liable to occur with the smaller parts of the flowers, like the ovaries and stamens. Keep your lens always at hand and be certain to use it.

(c) Carelessness and haste in reading and in studying the plants. Make haste very slowly. Be sure you are right in each step before making the next.

(d) Feeling that a plant must be *exactly* like a description. Plants were made before classifications and descriptions and some latitude must be allowed. Do not be content with the examination of one specimen of a plant. There are cripples among plants and yours may be one of them.

(e) Feeling that a description is *near enough right* when it is not. Only practice will enable you to tell

just how far to go and just what are the essential things.

B. Your uncertainties of vocabulary will be removed by a thorough study of the glossary and a review of the following sections of the *Foundations of Botany*:

Section 2, page 6, last paragraph.
Section 45, page 33.
Sections 48-52, pages 36-41.
Sections 79-94, pages 64-82.
Sections 132-139, pages 121-128.
Chapter IX, page 130.
Chapter XIII, page 186.
Chapter XIV, page 192.
Chapter XVII, page 217.
Chapter XVIII, page 221.
Chapter XIX, page 228.
Sections 382-394, pages 310-324.

It would be an excellent plan to re-read the whole of those references, checking the botanical terms used and learning their meanings accurately.

C. We are now ready for our real study of flowering plants. This must be from the plants. You must collect them as they grow, bring them home and study them there, keeping a record of what you find and where you found it.

For collecting, use a close tin box. Put your plants into this as soon as you have found them and keep the cover on. This will aid in preventing evaporation and tend to keep your plants fresh. When you find a

plant gather it entire or note accurately the parts you cannot conveniently take. You will need to know about the roots, leaves (those at the bottom of the stem are often different from those higher up, flower leaves differ from stem leaves), buds, flowers and fruits if possible. If the flowers are not perfect, look to see if the plant is monœcious. If it is not, try to find the other plant. Care in collecting will save trouble when you come to study. Search different localities for different kinds of plants and search the same locality at different times, a week or so apart. Do not get discouraged. You are learning every moment that you are looking.

D. When you have your plants ready for analysis and identification follow the following outline in ascertaining the facts. Do not begin the use of the *Key* till you have studied every point suggested here. Try not to destroy the parts as you dissect.

Root.
  Annual? Perennial? Form?
Stem.
  Endogenous? Annual? Direction of growth?
    Branched?
Leaves.
  Venation? Simple? Form. Outline, margin, tip? Surface? Stipules?
Flower.
  Perfect? Monœcious? Inflorescence?
    Calyx. Form? Number of sepals or lobes?
      Shape of sepals? Color? Free?

Corolla. Form? Number of petals or lobes? Color? Shape of lobes, corolla or petals? Free?

Stamens. Number? Hypogynous? Coherence? Color? Filament. Shape? Color? Attachment of Anther? Anther. Number? Number of cells? Shape? Color?

Pistils. Number? Adnation? Coherence? Compound?

Style. Number? Shape?

Ovary. Number? Simple? Number of cells? Shape?

Stigma. Number? Shape?

Fruit.

Character? Dehiscence? Cells?

E. When this is all done, take your *Key* and begin to trace the plant. You will find that new points need to be made out, as the outline is not sufficiently full for all cases. Turn constantly back to the flower for the information you lack. Do not be discouraged because the work is slow. It may take you several days to identify the first flower; after a while you will be able to analyze several in an hour. If you cannot get the first you try, lay it aside and begin on another. You will get them all right after a while.

F. When you have found the name of the plant, record it in your notebook which you can rule to show the various facts you want in connection with your work. The following facts are sufficient for your list:

The number of the specimen, the date, the family, botanical name, common name, locality where found, any interesting remarks. Send in the names of ten of the plants you have identified.

G. After your plant is identified, look it all over and think of it in the place where you found it. Try to get a general impression of it, see it as a whole, see it with its fellows. Study it until you will recognize it the next time you see it; learn its name and the name of its family.

H. Every time you add a new plant to your list try to make out any resemblances it may bear to other plants you have had. Wherein does it differ from other plants?

I. Take three plants, no two of the same genus, and press them between folds of drying paper, newspapers will answer with frequent changes. You will need flowers, leaves and part of the stem, together with root and fruit if convenient. Attach each of these securely to a sheet of paper upon which you have written the facts called for in studies D and F above. Send these three sheets in for correction and criticism. You may fold them if necessary, but if you do, fold them so that if your specimen is broken it will still remain with its own sheet.

TEST QUESTIONS

1. Draw a kidney shaped leaf with serrate edge.
2. Draw a netted veined leaf, that has three palmate lobes, each of them with an acute tip and a dentate margin.

3. Define umbel, catkin and panicle, and make diagram or sketch of each.

4. Distinguish between pedicel, petiole, stem, scape and peduncle.

5. Classify the organs of a complete flower.

6. Make a diagram of a cross section of a complete, perfect, symmetrical flower on the plan of five and label the parts.

7. What is a dicœcious plant? What is an irregular flower?

8. What are monadelphous stamens? Diadelphous?

9. What are parietal placentae?

10. Define epigynous.

LESSON XXII

Key and Flora

STUDIES

A. Enough assistance has been given you now so that you should be able to carry on the study of botany independently, and it is hoped that you have found enough lines of interest to keep you at work long after you have passed your final examination and earned your diploma. If the subject has been a success with you you will not measure your attainments by the certificate, but by what you have gained intellectually and esthetically. If the study has caused you to see more of the world around you, if it has taught you to look about you with interest in the beautiful things, if it has made you appreciate the wonderful powers and the perfect adaptation of plants to their environment, if it has led you to question the why and the wherefore of peculiar structures and to reason on the lives and uses of different forms of vegetation, if the world seems better, more beautiful, more wonderful, then you are a most successful student of botany, though you forget the difficult names and the troublesome scientific terms that often puzzled you.

B. You should now be able to analyze the simpler plants without great difficulty, and you should not consider this lesson finished till the list in your note-

book, described in the lesson preceding, shows at least fifty plants of different genera. Send in your list, giving the botanical names only.

C. Besides the list you should write out the abbreviated description of at least ten plants of different genera, using a form like the following. Write the outlines and then after each item write the one or two words necessary to describe. Be as brief, as explicit as possible. One word of description will usually answer. Here is the form, with the outline filled out for the *Johnny-jump-up :*

Family ..... Violaceæ .....
Genus ..... Viola .....
Species.... tricolor L. var. arvensis.
Common Name.—Johnny-jump-up.
Date.....May 29, 1906.....
Locality.....Washington, D. C.....
Root.....Perennial .....
Stem .....Slender, hardly erect .....
Leaves—
Venation ..... Netted .....
Simple or Compound.. Simple.....
Outline ..... Broadly ovate ..
Apex ..... Blunt.....
Base..... .....
Margin ..... Crenate .....
Petiole ..... Slender .....
Stipules..... Large.....
Flowers—
Calyx ..... Persistent.....
Sepals—Five, green, narrow, eared,
Corolla ....Rather small, short spur ...
Petals—Five, irregular, short, spurred, purple and orange ...
Stamens—Five, short. .....
Filaments—slightly cohering—two are spurred. .....
Anthers—Five, somewhat triangular.
Pistils..... One .....
Ovary ..... One-celled .....
Ovules ..... Numerous .....
Style ..... Somewhat club-shaped. .....
Stigma ..... One-sided .....
Fruit.—Pod—one-celled, three placentae....
Remarks.—Found by roadside near the city, just outside a garden gate. Rich soil.

Of course the facts will vary greatly and you will often wish to insert facts not provided for above.

Send in three descriptions with plants attached.

D. Learn to observe the general characteristics of flowers and fruits especially, so that in time you will recognize plants of the same family and even genera, at a glance. You will surprise yourself after a time with your proficiency in this way.

E. When you have found a plant belonging to what seems to be an important family, learn the description of the family, at least enough of the facts so that you can positively decide for yourself without the book whether a new plant belongs to the family or not. Here are some of the families that will demand your attention in this way because of the frequency with which you find them or because of their importance. It is not expected that you will learn all this now. This study may last for months.

1. Coniferæ—Pine family—page 13.
4. Gramineæ—Grass family—page 23.
5. Cyperaceæ—Sedge family—page 23.

   The species of the last two families are exceedingly numerous and are very difficult to determine. You can learn to recognize the two and to tell a grass from a sedge. That is enough.

10. Liliaceæ—Lily family—page 29.

    Best type of monocotyledons for you to study.

14. Salicaceæ—Willow family—page 47.

    You will find it impossible to distinguish many species but you can recognize the two important genera.

17. Betulaceæ—Birch family—page 51.
18. Fagaceæ—Beech family—page 55.
19. Ulmaceæ—Elm family—page 59.

The last four families are important as containing so many valuable trees. Learn to distinguish them and the principal genera. You will help to accomplish this by studying the book directly instead of waiting for the flowering of the trees. Trees are interesting and have much individuality. Learn to know them.

30. Caryophyllaceæ—Pink family—page 71.

Not so important as it is interesting.

32. Ranunculaceæ — Buttercup family—page 77.

Will give you many representatives in early spring.

39. Cruciferæ —Mustard family—page 93.

You will find many of them. The family is very easy to recognize but the species are difficult.

45. Rosaceæ—Rose family—page 105.

An important fruit-bearing family. Learn to recognize it by its *flower* and then to distinguish the genera, Pyrus (page 108), Cratægus (page110), Rubus (page 111), Fragraria (page 113), Rosa (page 115), and Prunus (page 116).

46. Leguminosæ—Pulse family—page 117.

Another very important family. Learn to recognize it from its fruit and from its papilionaceous (butterfly-shaped) flower. Pick out the important genera.

58. Aceraceæ—Maple family—page 140.

72. Umbelliferæ—Parsley family—page 158.
A large family containing both food plants and those of very poisonous character. Learn to recognize it from its peculiar flower cluster, the umbel. Difficult to determine the genera and species. Note Carum (page 160), Pastinaca (page 161), and Daucus (page 162).

75. Ericaceæ—Heath family—page 166.
A large family containing many useful and beautiful plants. Notice these genera Epigæa (page 169), Gaylussacia (page 169), Vaccinium (page 170).

87. Labiatæ—Mint family—page 193.
A large family of spicy and aromatic plants which you will soon learn to recognize by the flower, but whose species are difficult to determine.

100. Compositæ—Composite family—page 224.
An immense family of plants which you learn to recognize very soon by the composite heads composed of sessile flowers. The genera and species are often very hard to make out but you can determine some of them. There is the study of a lifetime in the Compositæ.

F. The eighteen families mentioned above you should know pretty well. After you have analyzed twenty or more flowers and understand and can interpret the descriptions, begin to look up and study the

descriptions of those families. You will find out that you already know many of these species, and you will be constantly finding new and unexpected relationships and can be on the lookout for new specimens of the different families.

G. If you wish you can prepare a herbarium. Some students find it a very interesting occupation. A herbarium is a collection of dried and classified plants. Begin by collecting typical plants and preserving the entire plant if you can. If not, be sure to get all the characteristic parts. Press them neatly between sheets of newspaper and leave them until perfectly dry. Put a label with each as you press it. The label should show date, locality and name.

When the plants are thoroughly dry, mount them on sheets of heavy white paper of uniform size. This is done by pasting narrow slips of paper across the plant and so fastening it to the sheet, or by gumming the plant directly to the sheet.

Another way of preserving is to lay the plant loosely between two folded leaves. This gives better opportunity for subsequent examination, but the plant is more apt to be injured. To each plant or to the sheet on which it is mounted fasten a label. Here is a good form:

Herbarium of John Jones.
Family. Violaceæ.
Name. Viola tricolor. L. var. arvensis.
Common Name. Johnny-jump-up.
Location. Roadside near Washington, D. C.
Date. May 29, 1906.

As your specimens increase in number, keep them arranged by families and genera, in the order in which they appear in the *Flora*.

TEST QUESTIONS

1. Give the most marked characteristics of two families of plants which you have studied.
2. Describe the cruciferous flower.
3. What unexpected relationships have you discovered between plants you formerly knew?
4. Classify flowering plants on the plan of the *Key* giving as examples at least one family and one species in each section of your classification.
5. What is the distinction between angiosperms and gymnosperms?
6. Define spadix, akene, and key or samara.

SHORTHAND

PREPARED BY

ARTHUR J. TAYLOR,
Principal of the Commercial Department of the Indianapolis High School.

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